Photocatalytic Treatment of Organic Pollutants in a Synthetic Wastewater Using UV light and Combinations of TiO_2, H_2O_2 and Fe(III)

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Highlights

- Effective carbon removal by means of $UV/TiO_2/H_2O_2$/Fe(III).
- Phenol, *2*-Chlorophenol, *2,4*-dichlorophenol, *2,4,6*-Trichlorophenol, *4*-Nitrophenol treated.
- Degradation of chlorinated compounds depended on the concentration of chlorine atom.

1. Introduction

Water pollution is one of the most significant problems worldwide and has adverse impact on daily life. Industrial growth and rise in population have resulted in high demand for water resources, whereas at the same time enormous amounts of various wastewaters are generated. Therefore, it is essential to make sure that disposed water is appropriately treated so as to ensure minimal impact on human health, aquatic life and environment. Although by means of conventional methods and especially of biological processes applied in a typical municipal wastewater treatment plant, 80-90% of all pollutants are removed, in some cases hazardous organic compounds can escape the facility [1]. In such cases, Advanced Oxidation Processes (AOPs) can be additionally utilized to eliminate toxic organic pollutants in wastewaters [2]. AOPs can be successfully used in wastewater treatment to degrade persistent organic pollutants, the oxidation process being determined by the very high oxidative potential of the •OH radicals generated into the reaction medium by different mechanisms [3].

The aim of the present work was to investigate the efficiency of the photocatalytic treatment of a synthetic organic wastewater with/without phenolic compounds by means of ultraviolet light and combinations of titanium dioxide as photocatalyst, hydrogen peroxide and ferric ions.

2. Methods

D – Glucose anhydrous ($C_6H_{12}O_6$), Sodium hydrogen carbonate ($CHNaO_3$), Potassium hydrogen carbonate ($CHKO_3$), Ammonium hydrogen carbonate (CH_5NO_3) and Peptone (a mixture of peptides and amino acids) were purchased from Fisher Scientific. Lab Lemco, which contains total nitrogen 12.4%, amino nitrogen 2.5%, and chloride 1.1%, was supplied by Oxoid. 2-Chlorophenol (≥99%), 2,4,6-Trichlorophenol (≥98%), and 4-Nitrophenol (≥99%) were supplied by Sigma Aldrich. 2,4-Dichlorophenol (≥99%) was purchased from Acros Organics. Titanium (IV) dioxide P-25 (≥99%) and Hydrogen Peroxide (37.6%) were obtained from Sigma-Aldrich. All reagents were used without additional purification and deionized water was used.

Experiments were performed in a batch-recycle annular photo-reactor with an ultraviolet lamp that had 6W input power and 254 nm irradiated wavelength. The total volume of the reactor was 250 mL with 55.8 mL effective volume (irradiated). UV lamp was placed inside the annular photoreactor and the non-irradiated part of the solution was stirred continuously with a magnetic stirrer. A pump by Heidolph was used to ensure 175 mL min^{-1} flow rate. An electrode LE409 by Mettler Toledo was immersed in the aqueous solution for continuous pH measurement.

Each experiment lasted for 120 minutes and samples were withdrawn periodically for the quantification of total carbon in the solution by Multi N/C analyzer by Analytik Jena AG, and the concentration of phenolic compounds using Agilent 1290 Infinity HPLC. Prior to analysis, samples were filtrated by means of Chromofil Xtra RC-20/25 filters with a pore size of 0.20 μm, purchased from Macherey-Nagel.

3. Results and discussion

When the surface of titanium dioxide is irradiated by UV light, it gets excited and a pair of electrons and holes are generated in the conduction (e^-_{cb}) and valence band (hv^+_{vb}) with reductive and oxidative capacity, respectively. The holes can either react directly with organic molecules or form hydroxyl radicals that subsequently oxidize organic molecules. The role of dissolved oxygen is important because it because it acts as scavenger for the photo-produced electrons and prevents thus the fast recombination between electrons and holes on the catalytic surface. The effect of TiO_2 concentration on the process is shown in *Fig. 1*. Many combinations and concentrations of titanium dioxide, hydrogen peroxide and ferric ions were tested in order to examine the most beneficial conditions for total organic carbon removal and target compounds conversion.

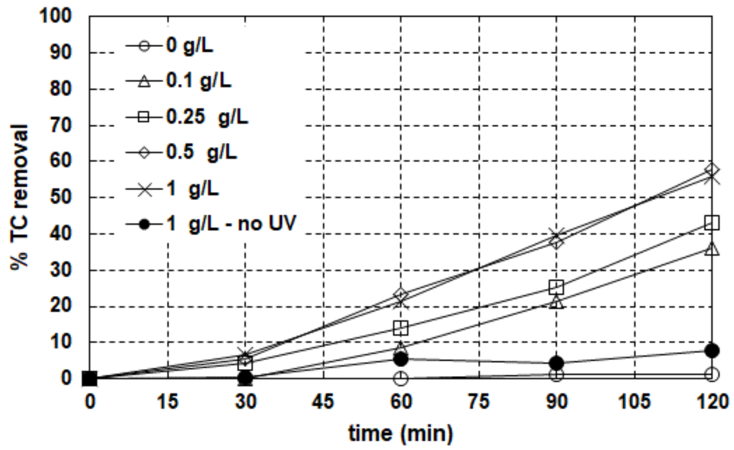

Figure 1. Effect of TiO_2 loading ($[TC]_o$= 32 mg L^{-1}).

4. Conclusions

In this study, the photocatalytic process was applied to treat a synthetic wastewater containing organic pollutants. The main results obtained are:

a. The UV/TiO_2/H_2O_2 process led to a 58% carbon removal for the initial conditions: $[TC]_o$ = 32 mg L^{-1}, $[TiO_2]_o$ = 0.5 g L^{-1} and $[H_2O_2]_o$ = 66.6 mg L^{-1}.

b. The UV/H_2O_2 process was considerably enhanced by the addition of ferric ions, resulting in 84% of carbon removal.

c. The application of UV/TiO_2 for the treatment of the wastewater containing phenolic compounds showed that the conversion of the phenolic compound was always higher than the corresponding total organic carbon removal.

d. The photocatalytic treatment in the presence of H_2O_2 was proved effectively in treating phenolic compounds present in the wastewater, achieving more than 80% of total carbon removal.

References

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Keywords

Photocatalysis; TiO_2; synthetic wastewater; UV.